Earth Science Subcommittee Report
September 27-28, 2006 Meeting
Adelphi, Maryland

From: The NASA Earth Science Subcommittee – Daniel J. Jacob (chair, djacob@fas.harvard.edu), Roni Avissar, John R. Christy, Lisa Curran, Jonathan Foley, James Hansen, Gregory Jenkins, John Jensen, Patricia Matrai, Julian McCreary, Jean-Bernard Minster, Michael S. Ramsey, Kamal Sarabandi, Mark Simons, Konrad Steffen, Edward Zipser
To: Edward David, Jr. (Chair, NAC Science Committee)
Cc: Mary Cleave (Associate Administrator for SMD), Greg Williams (NAC Executive Secretary), Bryant Cramer (acting ESD Director), Jack Kaye (acting ESD Deputy Director, Lucia Tsaoussi (ESS Executive Secretary)
Date: October 8, 2006

Dear Dr. David:

The Earth Science Subcommittee (ESS) met on Septermber 27-28, 2006 at the University of Maryland. We were delighted to learn of the reconstitution of the NAC Science Committee and congratulate you on your appointment as chair. We note that there is at present no Earth scientist on the reconstituted Committee but there should be at least one. We understand that some NAC appointments are still to be made, and **we recommend that at least one Earth scientist be appointed to the NAC Science Committee.**

We had very productive discussions at our meeting and report here on our recommendations concerning (1) the NASA response to the NPOESS de-scoping of its climate monitoring capability, (2) the NRC review of the NASA Science Plan (v3.0), (3) the Suborbital Science Program, and (4) Earth Science from the Moon and the upcoming Lunar Workshop.

1. De-scoping of NPOESS climate capability

In response to cost overruns and the ensuing certification process, NPOESS elected in June to de-scope its climate monitoring component while preserving its weather and security component. Six instruments intended to provide continuity in measurements of important climate variables were either eliminated or had their capabilities significantly reduced. These are: (1) solar irradiance; (2) outgoing IR radiation; (3) sea surface altimetry; (4) microwave sensing; (5) shortwave reflectance (mid-morning orbit); and (6) ozone vertical distribution. NASA was asked by Congress to assess the implications and to present an alternate plan for preserving continuity in long-term records of these climate variables.

NPOESS climate observations are critically important for our ability to monitor climate variability and change, and the fallout of the de-scoping in terms of decision support for climate change issues could be considerable. Monitoring of climate variability requires highly accurate measurements and long-term records with no data gaps, and this was

intended to be provided by NPOESS. We appreciate the new constraints placed by the NPOESS cost overruns, and so we examined the relative importance of the six de-scoped measurements. We ranked them in three priority levels: (1) absolutely critical – must be maintained; (2) very high priority – de-scoping would result in considerable loss; (3) lower priority – may be canceled if resources are lacking. Our list is as follows:

1. Absolutely critical: spectrally-resolved solar irrandiance (TSIS instrument) and outgoing IR radiation (ERBS). Continuous measurement of these variables is essential for a) monitoring the energy budget of the Earth and the associated radiative forcing of climate, b) determining the variability in solar energy output and its causes. These measurements can only be done from space to avoid atmospheric interferences. In view of the strong climate forcing presently being applied to the Earth by greenhouse gases and aerosols, and the highly uncertain role of solar variability in climate change, there should be no compromise in maintaining continuity of these observations. These are the two most fundamental measurements for monitoring climate change.

2. Very high priority: sea surface altimetry and microwave sensing (CMIS). Continuous sea surface altimetry is critical for observing sea level rise, one of the most direct and consequential manifestations of climate change. Microwave sensing of sea surface temperatures allows all-weather observations and thus avoids the clear-sky bias of IR sensing. Microwave sensing also enables observation of polar ice sheets and rainfall. Every effort should be made to avoid data gaps in these critical measurements.

3. Lower priority; mid-morning shortwave reflectances (mid-morning orbit for VIIRS) and limb ozone (limb capability for OMPS). Continuity in observation of spectrally resolved shortwave reflectances is of fundamental importance for a number of reasons including direct aerosol forcing and land-use change but this will be provided on NPOESS by VIIRS flying in an early-afternoon orbit. We do not see a very strong case for maintaining both mid-morning and early-afternoon records. In the case of ozone, continuous observation is critical for monitoring trends in the ozone layer, but the most fundamental measurement for this purpose is the total ozone column (OMPS nadir viewing capability) and this will be preserved on NPOESS. The OMPS limb capability provides information on the vertical distribution of the ozone trend with ~3 km resolution, and such information has been extremely useful in the past to interpret ozone column trends. However, we expect that some capability for monitoring trends in the vertical distribution of ozone will be maintained through the European METOP program (~ 8 km resolution) and through the ozonesonde network.

Losing the long-term continuous records of spectrally-resolved incoming and outgoing energy fluxes for the Earth system would be unconscionable, and losing the long-term global continuous records of sea-level rise, all-weather surface temperatures, polar ice sheet cover, and rainfall would be a tremendous setback. Restoration of these sensors on the NPOESS platforms should be seriously considered. An alternate solution would be to provide NASA with the resources to piggyback these sensors on its own launches. We favor the latter solution for the energy flux measurements and outline our reasons below in the context of the NRC review of the NASA Science Plan.

2. NRC review of the NASA Science Plan (v3.0)

We were appraised of the NRC Space Studies Board (SSB) and NASA Science Associates reviews of v3.0 of the NASA Science Plan. The NASA Science Associates review requires minor revisions and is straightforward to deal with. The NRC review is more substantial and we offer several recommendations for the ESD response to the most difficult points.

1. The NRC review asks that NASA better describe its strategy guiding the selection of missions. This criticism is justified in some areas of Earth Science but not in others. In Solid Earth, in particular, a detailed plan of action based on community input was described in the NASA-commissioned Solid Earth Science Working Group (SESWG) report (Sean Solomon, Chair) and in fact the SESWG report was reviewed in a NRC report (Ed Stolper, Chair). We are surprised that the NRC review does not acknowledge previous NRC reports on Earth Science except for those originating from the SSB. **We recommend that the Science Plan refer to these NRC reports.**

2. A prominent comment in the NRC review is a request that ESD develop a strategy for balancing new technology vs. long-term climate-relevant observations in its satellite mission planning. "Climate" is to be understood here in its broad IGBP definition as including the atmosphere, the oceans, the cryosphere, the land, the biosphere, and the lithosphere – that is, the interacting surface reservoirs of the Earth system. This has been a thorny issue for a long time and the de-scope of the NPOESS climate capability pushes it to the forefront. We cannot expect much guidance from the soon-to-be-released NRC Decadal Survey report, because the deliberations of that committee preceded the NPOESS cutbacks. The easy answer for NASA would be that, as a science & technology agency, it does not do climate monitoring. But this is not a satisfactory answer, particularly in the context of the NPOESS debacle. The Earth Science community has stated time and again the need for long-term monitoring of climate from space, and it has looked to NASA for leadership on this issue, as expressed by the NRC review. There are in fact three important reasons for NASA to take climate monitoring seriously. First, considering that long-term observation of climate variables is critical for climate science, one should view these observations as enabling the science. Second, introduction of new technologies can make long-term climate observations cheaper, more accurate, and more extensive, so that long-term observations and technology development do not need to oppose each other. Third, we clearly need a national strategy for long-term climate monitoring, and NASA is in a unique position to provide early leadership on this issue and encourage other agencies and the U.S. government to step to the plate.

We recommend that NASA take on the responsibility, until a more permanent solution is found, for continuity in space-based measurements of spectrally resolved solar irradiance and outgoing IR radiation. Our rationale for this recommendation is as follows:

a. It would demonstrate that NASA understands the need for preserving continuity in the records of these critical climate variables and is willing to provide leadership;

b. It would focus on the two most fundamental climate variables ('energy in' and 'energy out') for which long-term observation can be done only from space and for which long-term time series are certain to provide substantial scientific return;

c. It can be implemented at low cost by piggy-backing existing instruments on planned NASA launches. It would cause minimum sacrifice to NASA's priority of making new scientific measurements and developing new space-based technologies.

3. Another prominent comment in the NRC review is that the Earth Science Plan is too mission-centric and does not adequately explain the role of suborbital science and modeling in NASA's strategy. This echoed similar comments made in our own July review of the Science Plan and it should be addressed adequately in revision. Most of the basic text is already there in the document but it needs to be fleshed out and made more visible. **We recommend that the Science Plan emphasize more NASA's unique end-to-end capability for Earth Science, extending from the design and execution of space-based missions all the way to the exploitation of the data using advanced Earth Science models to serve human knowledge and societal needs.** This end-to-end capability enables NASA to (1) optimize the scientific return of its satellite missions, (2) plan the next generation of satellite missions on the basis of the best scientific knowledge. **We consider the Suborbital Science Program, involving NASA aircraft with detailed in situ and remote sensing instrumentation, to play a critical role as the link between space-based observations and Earth Science models; this role needs to be better expressed in the Science Plan.** Aircraft not only provide necessary validation for the satellite data, but also critical added value for successful assimilation of the satellite data into Earth Science models. This includes (1) correlative measurements not obtainable from space, (2) error characterization for use in data assimilation, (3) scale bridging between satellite observations, surface sites, and model grids.

4. The NRC review requests a strategy for including small satellite missions (ESSPs) into the ESD mission mix. As we have stated in our previous letters to the NAC, we believe that the strategic goals of ESD are in general best served by medium-sized missions (~$500M), and we expect in fact that the NRC Decadal Survey will mainly recommend missions of that size range. At the same time, we recognize that ESSP missions (~$350M) play an important role in the infusion of new ideas. **This complementary role of medium-sized missions (ESD strategic goals) and ESSPs (infusion of new ideas) should be more clearly spelled out in the Science Plan.** Because of the urgent need to get the Earth Science strategic goals on track, we have recommended a schedule for 2014-2024 of a medium-sized mission every 1-2 years and an ESSP every 4 years, and this schedule is now reflected in the Science Plan. As stated in our previous letter to the NAC, **We recommend if possible that the first mission to be competed**

in the future (AO in 2008, launch date in 2014) be a medium-sized mission instead of an ESSP.

5. The NRC review asks for clarification of the strategy by which NASA allocates its R&A resources. This stems from concern that an R&A program that doesn't fit clearly in ESD's overall mission is particularly susceptible to cuts. ESD has in fact a clear strategy for its R&A program but it needs to be better expressed in the Science Plan. As in the other Science Divisions, R&A in ESD is fundamentally driven by the satellite observations, but there are three factors that make ESD R&A more complex and larger than in the other Science Divisions: (1) the need to integrate the space-based observations with the many other observations of the Earth system, including in situ data and non-NASA remote sensing data; (2) the sophistication of Earth Science models, driven by the need to address pressing societal issues; (3) interest in the NASA satellite data from a large and diverse community of Earth Scientists, policy analysts, and stakeholders. This complexity is certain to increase in the future as the satellite data bases increase in quantity and quality, as the need to cross-link observations between different sensors becomes more pressing, and as the models place increasing demands on satellite data assimilation. **It is therefore entirely logical, in the context of a strong ESD program focused on satellite observations and with end-to-end capability, that the fraction of the overall ESD budget allocated to R&A should increase.** Here "R&A" should be taken to encompass the range of competed ESD scientific research activities including what is presently called "mission science" and "EOS science". **The Science Plan should better explain the relative roles of these different components of the ESD budget portfolio for scientific research, in particular how competed scientific funding actually extends beyond what is labeled "R&A".**

6. The NRC review request some indication of the strategy for infusion of new technology into the Science Plan. **The Science Plan could better describe ongoing new-technology efforts at ESD (such as laser reliability, microsatellites) and how these new technologies will be infused into the next generation of science missions.** For example, a future ESSP AO could include a requirement to use microsatellite technology.

7. The NRC review takes ESD to task for not implementing the recommendations of the 2005 interim Decadal Survey report. **We believe that ESD has accounted for these recommendations to the level that it could in consideration of its budget constraints, but the ESD Science Plan should acknowledge the interim report, its recommendations, and the constraints that prevented from implementing all these recommendations.**

8. **The NRC review requests a list or table comparing the 2003 and 2006 Earth science plans with explanations of changes, and we endorse this request.** Such information would vividly communicate the decimation of Earth Science research at NASA over the past 3 years. Even if the reduction in Earth Science budgets is halted and future funding rises at 1% per year for the next decade, as the current plan indicates, such an anemic sub-inflationary increase is in the long term a strategy for going out of business. NASA is being asked to do too much

with too little money, as pointed out by the recently released NRC report, "*An Assessment of Balance in NASA's Science Programs*". Current funding for ESD is vastly out of proportion with the large societal demand for Earth Science data and for improved knowledge of variability in climate and in the Earth system in general.

3. Suborbital Science Program

Our meeting included an extensive discussion of the ESD Suborbital Science Program. We commented in the previous page on the importance of this program. We are very pleased to hear that ESD is strongly committed to bring it financial and managerial stability. This is indeed essential for the user community to feel confident regarding the availability of airborne resources and to encourage effective demand and use of these resources.

We feel that there needs to be a better strategy for infusion of new technology in the program. The UAV development program is in particular need of attention because of recent difficulties involving FAA's restrictions on UAV operations. ESD should take a hard look at the goals of the UAV program in a manner that takes into account the severe constraints on operations that are unlikely to be relaxed soon. Strategies for technological infusion into the program should be done with community input. Workshops have been held over the past few years but do not seem to have resulted in the development of an adequate strategy. **We recommend that ESD appoint a Working Group for Suborbital Science to assist in the development of a strategy for new technology infusion and long-term planning in the Suborbital Science Program.**

4. Earth Science from the Moon and the Lunar Workshop

We reviewed and consolidated the list of Earth Science objectives from the Moon developed for the NAC at our previous (July) meeting, and reviewed the plans for the February Lunar Workshop (Michael Ramsey, Kamal Sarabandi, and Bernard Minster from the ESS serve on the Workshop Planning Committee). We endorse the workshop scope and objectives and we identified several potential speakers to contact. Our list of Earth Science objectives from the Moon (about 10 individual objectives) encompasses a broad agenda, with spectrometers of varying resolution operating over a wide range of wavelengths. A general Earth Observatory on the Moon would be of considerable value. This Earth Observatory would have specific technological and energy requirements, and require significant investments in new technology, which NASA would need to determine in consultation with the Earth Science community. We plan to work on engaging the Earth Science community in lunar observation issues between now and the workshop, including if possible a "Town Hall" meeting at the Fall AGU. In order to be most effective at the workshop, we recommend that ESD conduct preliminary mission studies for each Earth

Science objective. Effective presentation of the Earth Observatory concept will require high-quality graphics and we would like ESD to support some work in that regard.. **We recommend that a substantial plenary slot be given on the first day of the Workshop for a general presentation of Earth Science objectives from the Moon including description of the Earth Observatory concept.**

We hope that you find our comments helpful and are at your disposal for further information.

Sincerely,

The Earth Science Subcommittee